Aspect Ratio Effects on Neoclassical Tearing Modes from Comparison Between DIII-D and NSTX*

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Neoclassical tearing mode islands are sustained by helically perturbed bootstrap currents arising at finite beta from toroidal effects that trap a fraction of particles in non-circulating orbits. DIII-D and NSTX are here operated with similar shape and cross-sectional area but almost a factor of two difference in inverse aspect ratio a/R, which (to leading order) occurs explicitly in the destabilizing bootstrap current drive [$(a/R)^{0.5}$], in the small island size for stabilization [$\sim(a/R)^{0.5}$?] and in the relative effect of stabilizing curvature [$(a/R)^{1.5}$]. In these experiments, destabilized $n=1$ tearing modes were self-stabilized (reached the "marginal point") by reducing neutral-beam power and thus beta. The measure of the marginal island gives information on the small-island stabilizing physics that in part (with seeding) governs onset. The marginal island width on NSTX is found to be about three times the ion banana width and agrees with that measured in DIII-D, except for DIII-D modes closer to the magnetic axis, which are about two times. The balance in the Modified Rutherford Equation for tearing-mode stability at the experimental marginal point ($dw/dt=0$ for w_{marg} and <0 for all other w) indicates that while the stabilizing effect of the curvature term is negligible in DIII-D, it is important in NSTX. There is good correlation of the helically perturbed bootstrap term with the curvature in NSTX with near-zero offset; thus the curvature term dominates over the classical tearing stability index term. In contrast, the MRE balance in DIII-D is governed by the stabilizing classical index. The mode temporal behavior from the start of neutral beam injection reduction also suggests that NSTX here operates closer to marginal classical tearing stability; this explains why there is little hysteresis in beta between mode onset, saturation and self-stabilization (while DIII-D has large hysteresis in beta). The NIMROD code calculations based on DIII-D and NSTX reconstructed experimental equilibria also confirm the relative importance of the stabilizing curvature effect, an advantage for low aspect ratio; the relatively greater curvature effect makes for less susceptibility to NTM onset even if the classical tearing stability index is near marginal.

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